THE HISTOLOGY OF THE SKIN OF THE ELEPHANT.

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In dealing with the minute anatomy of the skin of the Elephant, I have found it necessary to divide it into certain parts for clearness of description. The skin of the trunk, ears, body, and limbs will therefore be separately described, for, as we shall see, they in some important respects differ widely from each other.

Trunk.—The skin of this region will be divided into that clothing the inferior or touch extremity of the trunk, and the body or main portion of that organ. It is not to be wondered at that the skin of this part should be of varying character, when we remember the remarkable prehensile and tactile power possessed by the lower extremity of the trunk.

The corium of the touch extremity is composed of white fibrous and yellow elastic tissue interlacing to form networks, and between which are found a varying quantity of muscular tissue of the striped variety. The meshes formed by the fibrous and elastic tissues are larger at the deeper than at the superficial portions of the skin, for here they run closer together to form the papillary portion of the corium. The corium rests upon the muscular tissue of the trunk, and fibres from this part pass outwards through the corium and reach to nearly the most superficial parts of the layer. The mean thickness of the corium is $\frac{1}{8}$ of an inch. The papillæ formed are remarkable for their extreme length—they are long finger-like processes, lying close together, and passing directly outwards to reach the superficial layers of the epidermis; the fibrous tissue of which they are composed takes rather a wavy direction, and the papilla itself ends in an obtuse point within a short distance of the surface of the skin (fig. 1). As a rule, the papillæ are single, but sometimes they are multiple, viz., two or three arising from one base. The length of these papillæ will be found to be from $\frac{1}{20}$ to $\frac{1}{30}$ of an inch, and their width at the base from $\frac{1}{100}$ to $\frac{1}{200}$ of an inch. Blood-vessels, nerves, and even muscular fibre may be seen

running up quite close to the base of the papillæ, but I have never distinctly traced any of these into the substance of this part, though, of course, the papillæ are composed largely of nervous material.[1] Their undoubted use is to supply that delicate and perfect sense of touch possessed by this animal, and to this purpose the papillæ are in connection with certain nerve-endings which are found scattered throughout the corium of the touch extremity.

These nerve-endings are irregularly oval in outline, and are composed of concentric layers like an onion, the central portion or nucleus being solid and granular (figs. 1 and 2). They are of great size, varying from $\frac{1}{60}$ to $\frac{1}{80}$ of an inch in length, and $\frac{1}{140}$ to $\frac{1}{160}$ in width; the central portion or nucleus being $\frac{1}{600}$ to $\frac{1}{700}$ of an inch in diameter. These nerve-endings are scattered throughout the superficial portions of the corium, generally beneath the papillæ, and are either single or exist in small groups of two's and three's. I have only once been able to trace a blood-vessel into them, and it has not been possible to more clearly define their arrangement. This is owing to the tissue being stale. The trunk is the only part of the elephant's skin where we find special nerve-endings. I have not been able to clearly define the area over which they extend, but I am cerrtain that they exist in larger numbers on the touch extremity than elsewhere.

The blood-vessels in the corium are numerous and large, but have no special distribution.

In no part of the skin of the Elephant can sebaceous or sudoriferous glands be found, and the trunk is no exception to this rule.

The epidermis covering the touch extremity of the trunk is enormously thick, and arranged, as in other animals, in layers of cells fitted into each other with the most perfect regularity. These cells take, of course, the general contour of the skin at this part. In bold masses they sweep up the side of the long papillæ, forming a large convex cap for the summit, and immediately descend on the opposite side of the prolongation. The deeper cells contain a large amount of pigment. The

[1] The reason I have not been able to absolutely demonstrate the nerves by staining is on account of working with material six years old.

epidermis, which is found to cap the papillary process of the corium, is sometimes arranged in rather a singular manner I cannot better describe it than by saying that at the top of the papilla is a space containing a number of cells; in my notes I have spoken of it as a nest of cells, and perhaps this is the best term to use for it; these nests grow outwards, so that some are found in the middle of the epidermis and some on its surface. Surrounding the nests are the epidermal cells, many of them being spindle-shaped. The cells occupying the nests are generally round or oval, and somewhat resemble cartilage cells, the nest itself being formed either of a fibrous-looking material, or by means of the spindle-cells previously alluded to. Some large spindle-shaped or oval cells may also be found in groups (not arranged distinctly in nests) scattered through the substance of the epidermis, which in some cases are strikingly like cartilage cells, and possess a large oval or round nucleus. This arrangement of cell "nests" exists in other parts of the body, particularly in the skin above the nail, and in the nail itself.

The general arrangement of the pigment in the epidermis is to cause it to present under a low power an appearance of black streaks extending from the corium to the surface of the skin, separated by means of cells which are comparatively free from pigment.

The thickness of the epidermis is from $\frac{1}{8}$ to $\frac{3}{16}$ of an inch.

In the upper part of the Trunk the long papillæ have disappeared, and their place is taken by what I will have to describe as compound papillæ, viz., there is a large primary papilla, and from this several smaller secondary ones grow (fig. 3). Muscular tissue is still largely present in the part, and the same special nerve-endings are to be found; hairs, however, are to be seen here, which are almost absent from the touch extremity of the organ.

The Skin of the Ear is remarkable for its extreme vascularity, and the comparative thinness of the corium and epidermis. The papillary layer of the corium consists of primary and secondary papillæ, the primary being somewhat cone-shaped, and the secondary varying in number from two to nine. The rete Malpighii is thickest in the centre of the primary papillæ, and

diminishes to a mere streak at the extremities of it. Hairs are found in this skin.

The Skin of the Body.—The corium is of considerable thickness, about $\frac{1}{16}$ of an inch; it is composed wholly of white fibrous and a little yellow elastic tissue, interlacing in all directions, and forming large spaces below and small ones above. The papillæ are of the compound order, viz., a large primary papilla, which is an archway-like projection $\frac{1}{16}$ of an inch at its base, and projecting upwards for the same distance into the epidermis, from the upper surface of this archway the secondary papillæ are given off, being from eleven to fifteen in number, and having a length of $\frac{1}{200}$ to $\frac{1}{250}$ of an inch, and a base of from $\frac{1}{250}$ to $\frac{1}{350}$ of an inch.

The nerves of the corium are numerous, giving off loops to the primary papillæ, which in turn give off branches to the secondary papillæ; occasionally a main trunk enters a primary papilla, and breaks up into secondary branches. There is no regularity in their distribution, and I do not think that every secondary papilla has a nerve.

There is not a trace of glandular structure in this skin.

The epidermis of the skin of the body is arranged much as elsewhere, the deepest cells being very large, nucleated, and containing much pigment. Again, we notice the extreme regularity of the cells, both large and small, comprising this layer. The general direction of the cells corresponds to the outline of the papillæ; at the depression where two papillæ meet the amount of pigment is very great, and as this is continued outwards through the layer, it gives the part a laminated appearance. The epidermis is about the $\frac{1}{50}$ of an inch in thickness.

The skin of the limbs was examined particularly at the margin of the nails. The corium is from $\frac{3}{8}$ to $\frac{9}{16}$ of an inch in thickness, and is remarkably vascular; its papillæ are both compound and single, the latter predominating close to the nail, and being there in shape much like those found on the touch extremity of the trunk, with the exception that they all appear to be vascular papillæ, and large convoluted vessels run into them quite close to the termination of the epidermis. The convoluted vessels strikingly reminded me of what a sweat gland would be if elongated; in fact, I thought at first these must be glands, but

I feel convinced that they are blood-vessels. They are the $\frac{1}{1000}$ of an inch in diameter, and the plexus is $\frac{1}{12}$ of an inch in length.

I could not determine any special nerve-endings at this part. The epidermis on the skin above the nails is very thick, and resembles that found on the touch extremity of the trunk; as we get nearer to the nail the appearance is more like horn; in fact, it is impossible under the microscope to say exactly where the skin ends and the horn begins. The large vascular papillæ, with the convoluted vessels mentioned above, run only into the epidermis a little above the nail, but not into the wall of the nail itself. The papillæ from the corium immediately above the nail extend into the epidermis and nail wall for a distance of from $\frac{1}{8}$ to $\frac{1}{16}$ of an inch. I observed in the epidermis of this part the same cell collection, or cell "nests," found on the touch extremity of the trunk.

The *Hairs* in the skin of the Elephant may broadly be divided into two classes,—hairs and bristles. The former are much finer than the latter, which are coarse, powerful, and of great length. The microscopical differences are also very great; the hairs are mainly solid in their structure, whereas the bristles are perforated for a considerable length by foramina. I am not prepared to say whether a hair ever grows into a bristle, but I am confident that in the animal's skin we find these two distinct classes. Before describing the appearance of a hair, it will be necessary to look at the sacs in which it is enclosed.

On making a section of the skin of the trunk, we are struck by the appearance of certain greyish, pear-shaped bodies, of such remarkable size that they are readily seen by the naked eye; in length they are $\frac{3}{8}$ of an inch, and in their greatest diameter $\frac{3}{16}$ of an inch (fig. 7). These bodies are the hair follicles, or perhaps more correctly the bristle follicles, for the hairs are contained in a smaller sac, which never reaches such a size as that of the bristles. The sheath of the bristle follicle is greyish in colour and very tough, and may microscopically be readily separated into an external and internal sheath. The internal sheath is smaller than the external; in structure it is cellular and fibrous, the two appearing to alternate; in a longitudinal section the one layer is seen above the other; in transverse section the

fibrous layer is seen to throw out projections towards the external root-sheath, and to be arranged around it in a somewhat radiating manner; between the limbs thus thrown out we see the cellular structure, which is almost exactly like cartilage. Externally this follicular sheath is in contact with the external sheath of the follicle. The two are intimately blended, but by exercising a little pressure on the section, it will be seen that they fit into one another by means of the processes from the internal follicular sheath.

The papilla of the hair or bristle rests on the internal sheath of the follicle; this sheath is here comparatively narrow, and its structure is principally fibrous, containing many connective-tissue corpuscles. The internal sheath of the hair-follicle stains quite differently with picro-carmine from the external sheath, taking on a much lighter carmine tint. The vascularity of the internal sheath of the follicle is also remarkable, and it is highly endowed with nerves.

The external sheath of the follicle is much more fibrous and larger than the internal sheath, and consists of bundles of fibres interlacing in all directions. It stains of a deep red with picro-carmine. Though with the naked eye it is easy to determine the sharp outline of this sheath from the surrounding corium, yet under the microscope it is rather difficult to say where one ends or the other begins.

Surrounding the hair or bristle we have the internal root-sheath, and outside this the external root-sheath, which in turn lies in contact with the internal sheath of the follicle.

The internal root-sheath is a vitreous layer enveloping the shaft of the hair; in small hairs it is the $\frac{1}{500}$ of an inch in diameter, whilst in the bristle it is from $\frac{1}{300}$ to $\frac{1}{200}$ of an inch in diameter. In transverse sections it is seen to be composed of an imbricated layer of glassy cells, those next the hair being the smallest, whilst those outside them are large and irregular in outline, and lie over each other. In longitudinal sections the cells appear to take a more definite direction, but are just as structureless and glassy in appearance. This sheath passes under the hair, but terminates at the papilla; it is quite impossible to stain it.

The external root-sheath does not pass down to the bottom

of the hair; it is much narrower below than above, where it enlarges considerably. In structure it is cellular, the cells being large, oval, and nucleated. Those cells next to the vitreous layer are arranged diagonally to the hair, whilst the cells nearest to the internal sheath of the follicle are horizontal. This layer stains orange-red with picro-carmine, presenting a marked contrast to the vitreous layer. I have often observed a dark irregularly broken line separating the internal from the external root-sheath. The outer zone of the external root-sheath is always more opaque than any other part. The diameter of the external root-sheath varies from $\frac{1}{500}$ to $\frac{1}{300}$ of an inch.

The papilla of the hair or bristle is formed by the internal sheath of the follicle; it is largely cellular in structure, and I believe that prolongations from it pass up into the foramina found in the bristles, but on this point I am not positive.

The hairs and bristles are black in colour; both may be found on the body, but I think the bristles are more plentiful on the trunk and tail than elsewhere. I recognise the bristles by their being much coarser than the hairs, and by possessing a much larger sac; this latter reaches its full development in the trunk.

Both hairs and bristles penetrate the skin obliquely, and run into it for a distance varying between $\frac{1}{4}$ to $\frac{1}{2}$ an inch; they gradually decrease in thickness as they pass outwards; the bristles are 3 or 4 inches long, the hairs about half this length.[1] The bristles on the tail (which I have not had an opportunity of examining microscopically) are of immense thickness and length.

If a longitudinal section of a bristle be made, and that portion examined which is outside the skin, a number of dark lines of pigment may be seen running the length of the bristle, separated by a substance much lighter in colour. These streaks indicate the remains of the canals or foramina. If that portion of the bristle which is within the skin be examined in longitudinal sections, the canals are there seen not as perfectly clear spaces, but much lighter in colour than the parts on either side of them. If we take a bristle and make transverse sections of it from the

[1] I am here only referring to the specimens in my possession; it is most likely that the length of these appendages varies considerably according to climate and season.

root upwards, it will be found that the foramina do not run the length of the bristle, but cease about on a level with the epidermis. The foramina are twenty or thirty in number, and oval or round in outline (fig. 5). Surrounding these openings we have the cells of the hair arranged in a concentric manner, and the appearance presented under a high power is strikingly like bone, only that the laminæ formed by the hair cells are very small. The cells forming the hair or bristle substance are of the pavement variety, each cell containing a large black nucleus; around the foramina the cells become flattened. The canals in the hair are not empty, but contain highly refractile cells like the internal root-sheath; on section many of these fall out and thus leave the part perfectly clear.

The hairs are solid for the greater part of their length, and many of them may be solid throughout, but there can be no doubt that I have detected foramina at the deepest part of many hairs just above the papillæ (fig. 6). They do not run up the shaft for any great distance, nor have I seen them in all specimens examined, but there can be no doubt that many of the hairs on all parts of the body contain foramina filled with vitreous-looking material.

The diameter of the bristles is about the $\frac{1}{30}$ to the $\frac{1}{40}$ of an inch, the measurement being made close to the papilla; as they pass higher up in the skin they get narrower. The foramina are from $\frac{1}{1000}$ to $\frac{1}{500}$ of an inch in diameter. The hairs are from $\frac{1}{160}$ to $\frac{1}{120}$ of an inch in diameter; some on the body are double this size.

The Nails of the Elephant.—In describing these, I am compelled to use the nomenclature adopted in describing the hoof of the Horse. Thus the nail has a wall and a sole; the wall is crescentic in shape above and at this part is very thin; it gradually increases in thickness to about $\frac{3}{8}$ of an inch, and maintains this all the way down. On the internal surface of the wall are a number of horny laminæ or leaves, which fit in between a corresponding number of sensitive laminæ, which are found on the outside of the bone of the nail (fig. 8). The horny laminæ, unlike those of the Horse, extend for a short distance on to the horny sole. The horny laminæ do not reach within an inch of the top of the wall, but where they exist are as well developed as in the Horse. The sole of the nail is very thick—

about $1\frac{3}{4}$ inch. On the upper part of the sole, next to the sensitive foot, are a large number of foramina of great size to accommodate long villi growing from the sensitive sole. The width of the nail, from corner to corner, is 5 inches, and its height at the centre $2\frac{1}{2}$ inches.

A transverse section of the wall, including the laminæ, when viewed microscopically, is found to differ, depending upon whether the section is from the centre or sides of the nail, or whether we are studying the wall or the leaves; the latter are cone-shaped, and possess certain lateral irregularities corresponding to the lateral laminæ of the Horse. The laminæ terminate either in an obtuse point or in two or more projections. In some places it may be seen that the laminæ are bridged across, and thus a canal or foramen formed. This is particularly the case with the corners of the nail rather than its central portion. Here we find the laminæ more obliquely placed, and lie closer together, and they are bridged across or connected by a tissue which is undoubtedly horn, and yet in some of its characteristics is wholly unlike any other horn with which I am acquainted. The bridging across of the laminæ leads to the formation of many foramina, and I am satisfied that I have found that those next to the sensitive tissue often contain a blood-vessel.

The union of the horny laminæ with the wall of the nail is peculiar. The laminæ appear to pass into the wall and then become fibrous in appearance, the fibres being remarkably wavy, and, curving up and down both to the right and left unite with similar fibres passing from the neighbouring laminæ. So far as the centre of the wall is concerned we observe nothing else of importance in connection with this structure, but at the lateral edges of the nail we find that the fibres of the horny laminæ enclose long strips of tissue, penetrated by some large canals, and that around these canals we have fibres disposed in a circular manner, and an appearance of lacunæ produced by the pigment existing in the horn cells. This structure, which I have previously mentioned above, is so singular that it can only be understood by the aid of the drawing (fig. 9). The contents of the canals are cellular, though one, as I noted above, often contains a blood-vessel. The cells which fill the others are

large, round or oval, and readily stain with carmine, presenting a great contrast to the surrounding horny tissue, which is stained yellow by picric acid.

On examining with the naked eye a section of the wall which has been stained with picro-carmine, we find that the horny laminæ take on a decidedly carmine tint, forming a marked contrast to the yellow wall.

I am quite certain that some of the large canals just spoken of contain a blood-vessel (it is generally contained in that canal nearest to the sensitive laminæ), but I am not clear on the point as to whether nerve-tissue is found in them, though on three occasions I have seen a body in the canal closely resembling the nerve-endings found in the trunk.

The structure of the wall proper is simple; it consists of foramina and inter-foraminal tissue. The latter is composed of epithelial cells, each one containing a small nucleus; towards the canals the cells become compressed and elongated, constituting the rings or laminæ we see surrounding the canals; the latter are oval or elongated; the largest ones are found nearest to the sensitive structures of the foot, those situated anteriorly are narrower but longer. They take the carmine dye readily, whilst the surrounding tissue is stained yellow; the canals are filled with elongated cells, and it is these which, taking the carmine dye, give the colour to the part (fig. 10).

The structure of the sole is very much like that of the wall, only that here the canals nearest to the sensitive part are of considerable size, to accommodate long sensitive papillæ which pass down into the depth of the horny tissue for about half an inch; below this the canals get much smaller, and the structure closely resembles the wall. We must for a moment amplify the description given of the upper part of the sole. Here we find well-marked horny rings surrounding the canals, and the cells of these laminæ contain a nucleus closely resembling lacunæ; so much does this appearance resemble bone tissue that I think it possible for even an experienced microscopist to fall into an error respecting the structure if examining an unlabelled slide. The contents of these canals are stained carmine.

The points of interest in the skin of the Elephant I believe to be these—

Fig. 1.

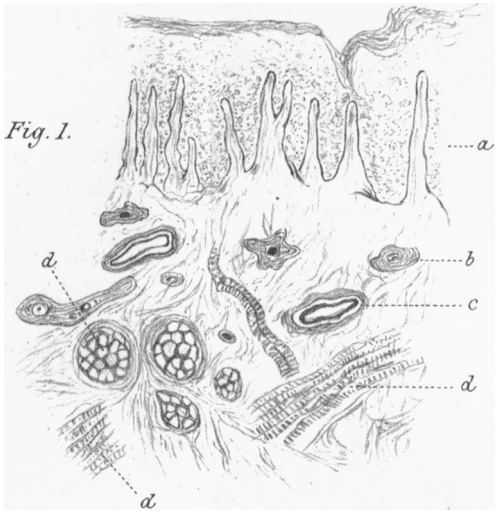


Fig. 2.

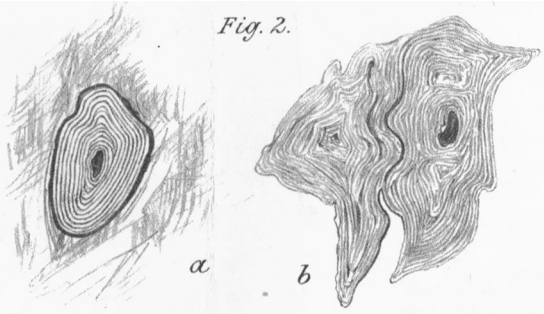


Fig. 3.

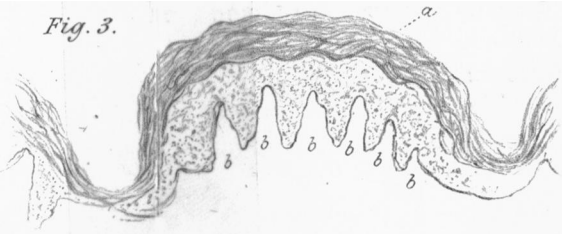


Fig. 4.

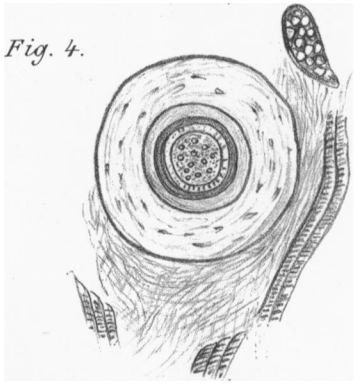


Fig. 5.

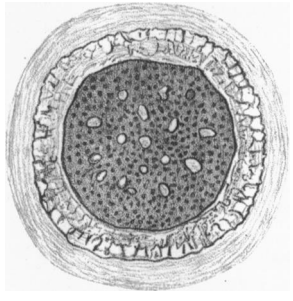


Fig. 6.

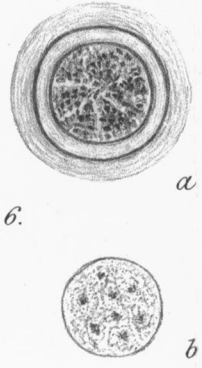


Fig. 7.

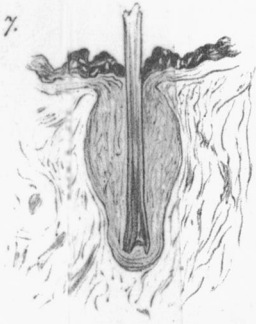


Fig. 8

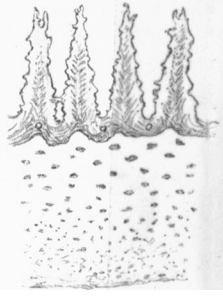


Fig. 9.

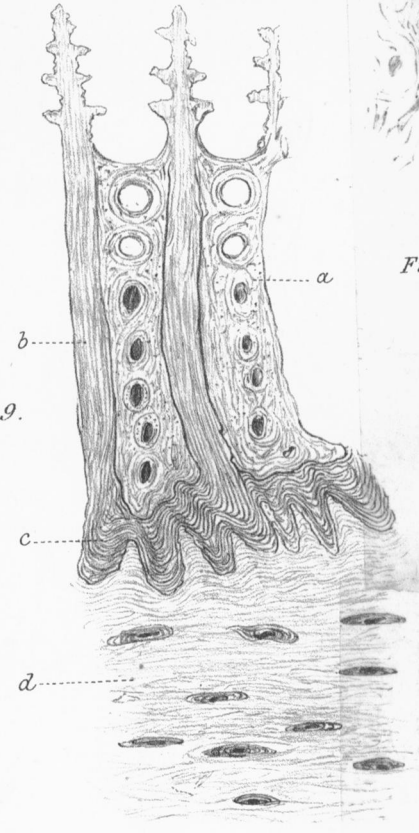


Fig. 12.

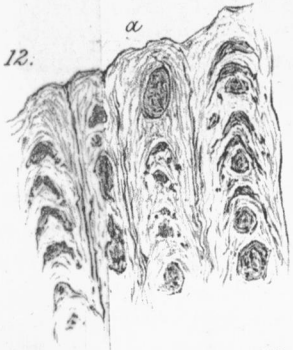
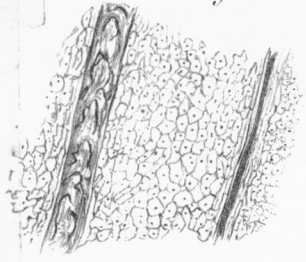


Fig. 11.

Fig. 10.



F. Huth, Lith.r Edin.r

SKIN OF ELEPHANT.

1. The long finger-like papillæ on the tip of the trunk placed in connection with special nerve-endings, and no doubt conveying that exquisite sensibility which the animal is known to possess in this part.
2. The compound primary and secondary papillæ in the skin.
3. The absence of anything approaching glandular structure.
4. The canal system which exists in all bristles, and in a modified degree in most hairs.
5. The arrangement of the horny and sensitive laminæ at the corners of the nail, and the presence of a blood-vessel in true horny tissue.

From careful inquiries made of competent persons, I believe that the skin of the Elephant has not been previously described.

EXPLANATION OF PLATE XVIII.

Fig. 1. Section of skin on the touch extremity of the trunk. *a*, the long finger-like papillæ; *b*, nerve-endings; *c*, blood-vessel; *d*, muscular tissue.

Fig. 2. Nerve-endings in the trunk. *a*, single; *b*, multiple.

Fig. 3. Primary and compound papillæ. *a*, primary; *b*, compound.

Fig. 4. Section of bristle from the trunk with enveloping sacs.

Fig. 5. The bristle, with inner and outer root-sheaths more highly magnified. In the drawing the inner root-sheath does not possess the vitreous appearance shown in the specimen.

Fig. 6. *a*, Hair and sheaths from the body—the position of the canals is indicated by the collection of pigment cells; *b*, a thinner section of hair showing the position, or rather remains, of canal structure.

Fig. 7. Position of the bristle and sacs in the skin of the upper part of the trunk.

Fig. 8. Section of wall of nail showing horny laminæ. The proportion between the length of the laminæ and width of the wall is not preserved in the drawing.

Fig. 9. Section of wall taken from the corner of the nail, showing *a*, the horny tissue between the laminæ; *b*, the laminæ; *c*, the remarkably wavy course taken by the fibres of the laminæ; *d*, the foramina in the wall of the nail.

Fig. 10. Longitudinal section of the wall showing the canals.

Fig. 11. Convoluted vessels found in the papillæ of the skin above the nail. They run for a considerable distance into the epidermis.

Fig. 12. Portion of epidermis from the surface of the skin above the nail. *a* is the surface of the skin. The epidermis is crowded with cell-nests.